Modelling European Agriculture with Climate Change for Food Security

Assessing priorities for enhancing adaptive capacity of agricultural systems to climate change using fuzzy logic-based approaches

Gianni Bellocchi[1], Maria Laura Ruiu[2], Francesco Piras[3], Pier Paolo Roggero[4], Giovanna Seddaiu[4]

1. UMR Ecosystème Prairial, INRA, VetAgroSup, Clermont-Ferrand, FR
2. Department of Social Sciences, Northumbria University
3. ISMEA, Direzione Servizi per lo Sviluppo Rurale, Rome, Italy
4. NRD and Dipartimento di Agraria, Univ. Sassari, IT

MACSUR Science Conference 2017, May 22-25, Berlin

Rationale

- The **framing** of adaptation influences the nature and effectiveness of responses (Wise et al 2014, GEC)
- Contextualized adaptation **pathways**, not targets
- Emerging new **design praxes** to open opportunities for adaptive capacity to be enhanced (e.g., Colvin et al 2014, Res Pol)
- Stakeholders trust and agreement are key drivers for effective decision making (Vermeulen et al 2013, PNAS)
  - Consesus beats reality!
  - Good enough is best!

Objective

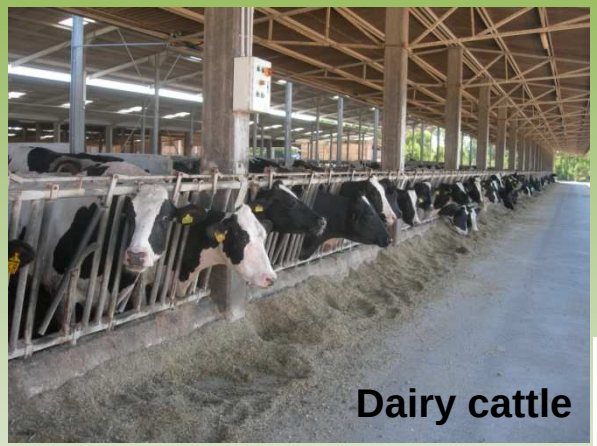
To identify effective, locally meaningful and feasible strategies to adapt to climate change of rural communities in the Oristanese district through…..

…….a long lasting co-learning process between researchers and stakeholders to identify priorities and

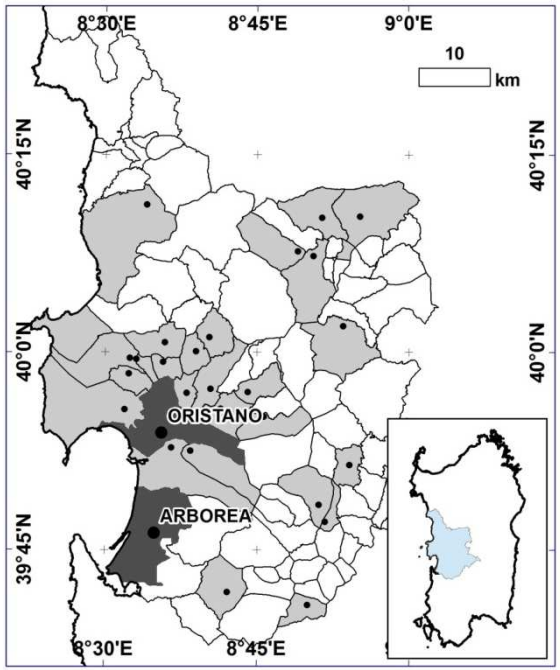
……the application of a fuzzy logic-based approach to develop a composite indicator of the adaptive capacity (AC) to climate change

Case study area

Farming systems in the district of Oristanese



EU Nitrate Directive → Regione Autonoma della Sardegna (01/2005) → "Nitrates Vulnerable Zone" (NVZ)



Irrigated forage systems :
•silage maize, Italian ryegrass, triticale, alfalfa

Permanent or temporary pastures in rotation with autumn-winter forage (winter pasture and hay or grain production)

Case study area

Other economic activities in the district of Oristanese

Tourism, bird watching

Fish farming

Research methods – Phase I

Identifying priorities and indicators

A set of strategic priorities for adapting to contextual changes were identified by an **interdisciplinary team of researchers** as informed and shaped by **interactions with stakeholders**

Research methods – Phase II
Identifying priorities and indicators

- **Extending and coding** priorities by a **questionnaire survey:**
  - 31 local key-stakeholders involved (scientists, farmers' Cooperative managers, farmers, consumers, water association officers, environmentalists)
  - Identifying additional priorities
  - **Attributing the score** to a list of priorities (1-5 scale; 1: no important to 5: very important)

Research methods – Phase III

Identifying priorities and indicators

- A sub-set of priorities was identified and converted into a quantitative indicator according to:
  - Relevance for SHs (scores ranking)
  - Availability of data

- **21 resulting priorities ⟶ 21 indicators**





Research methods – Phase III

Identifying priorities and indicators

Macro-area	Priorities
Priorities for rural economic development	Increase employment and local economic development
	Internationalization → support innovative market strategies
	Generational turnover
Priorities for farms' development	Decrease of production costs
	Easy access to credit
	Efficient use of natural resources (e.g. water)
	Efficient irrigation systems
Priorities for environment	Mitigate and adapt to climate change impacts
	Pollution reduction (conditionality)
	Reduced use of agro-chemicals
Priorities for research and education	Support education (school, University etc.)
	Scientific knowledge development
	Enhance Public and Private investments in Research & Development
Additional priorities	Promote actions for rural development (x3)
	Innovations in systems of production (x2)
	Investments on participatory governance and influence on policy making
	Investments in the young labor force
	Activism

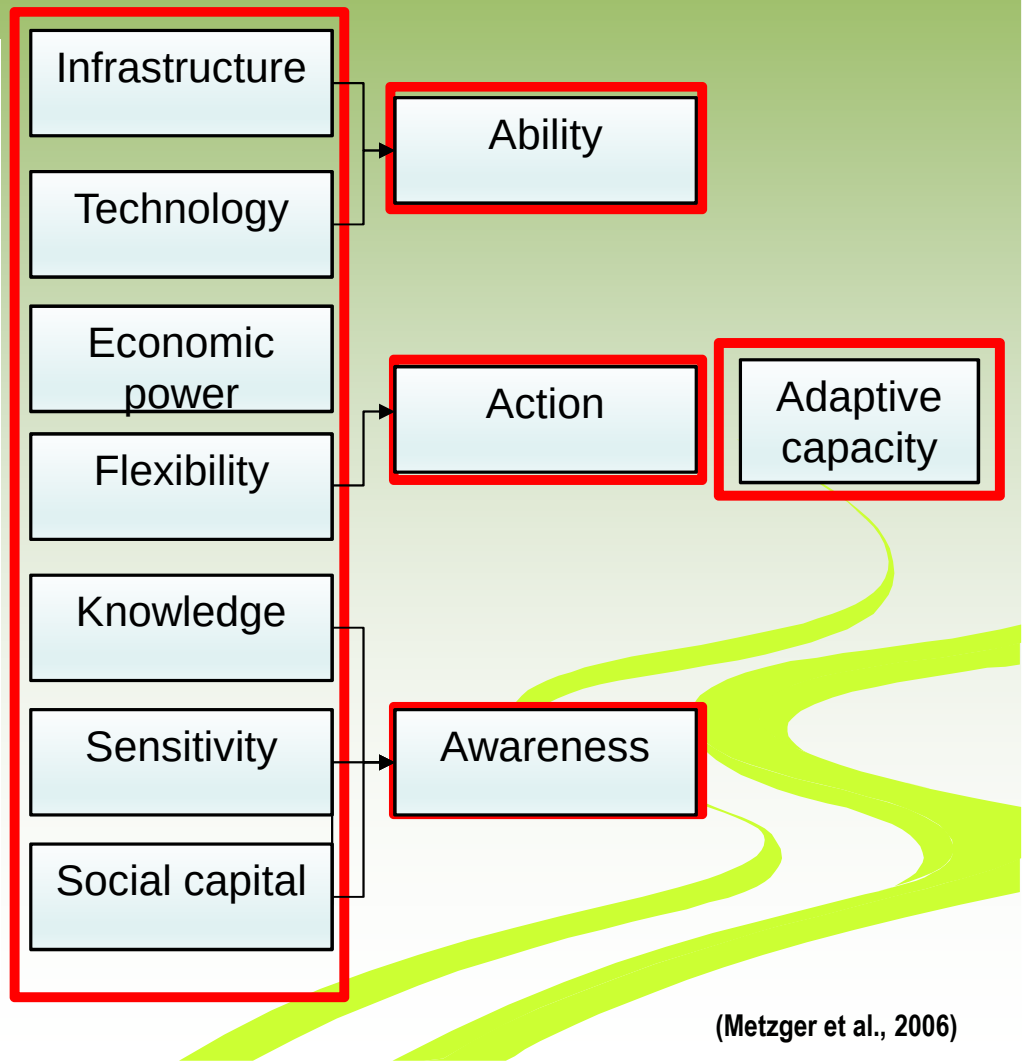
Framework used to develop the adaptive capacity model

Macro-areas → Priorities → Indicators → Determinants → Components → Index

4 macro-areas

21 priorities

21 indicators



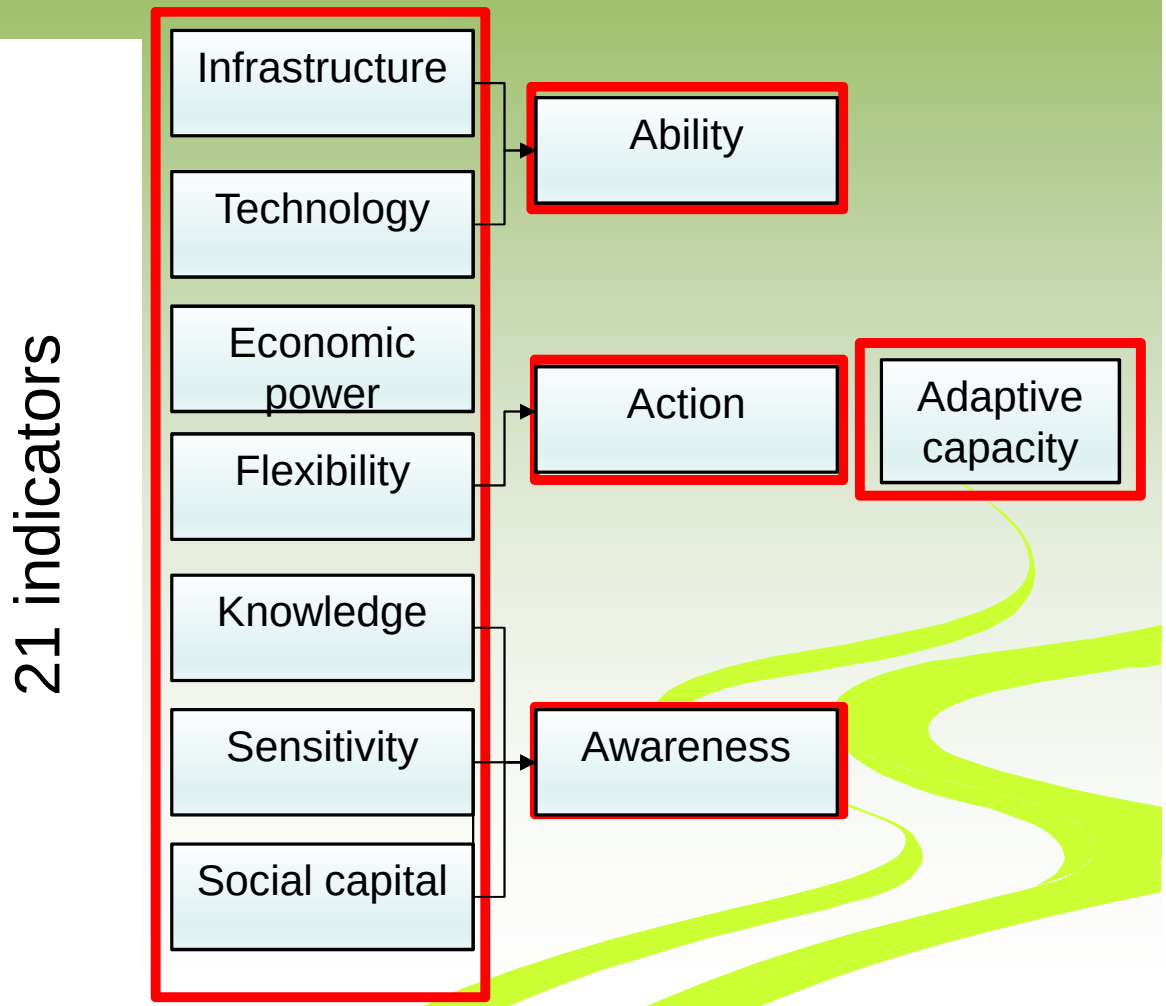
(Metzger et al., 2006)

Framework used to develop the adaptive capacity model

Macro-areas → Priorities → Indicators → Determinants → Components → Index

Following the framework proposed by Metzger et al 2006. Agric. Ecosys. Environ.:

- Each indicator was aggregated into determinants
- Each determinant was aggregated into components

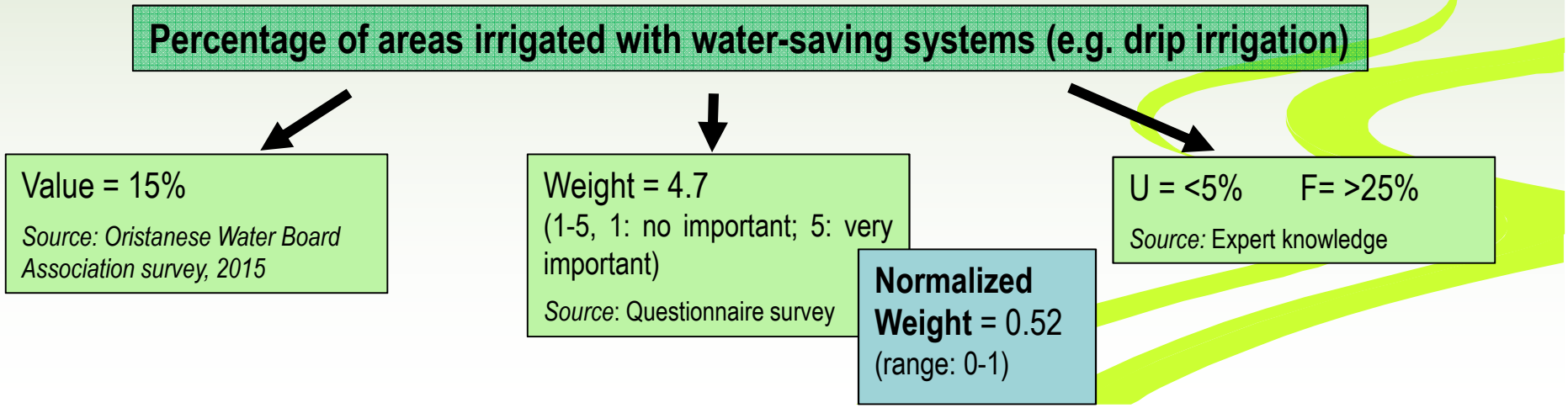


(Metzger et al., 2006)

Research methods – Phase IV

Fuzzy logic-based approach

- For each indicator the following figures were identified (based on expert knowledge, surveys, census, literature data, etc.):
  - Value (the most recent available)
  - Weight (relevance)
  - Unfavourable (U) and favourable (F) thresholds



Results





Sardinian case study : adaptive capacity

Priorities	Determinant	Component
A Innovations in agricultural production systems = 43 (F = 70, U = 35) B Efficient irrigation systems = 15 (F = 25, U = 5)	Infrastructure	Ability
C Scientific knowledge development = 0.7 (F = 0.7, U = 0.4) D Public and Private investments in Research & Development (R&D) = 0.1 (F = 0.7, U = 0.4) E Innovations in systems of production_1 = 23 (F = 34, U = 24) F Innovations in systems of production_2 = 3 (F = 98, U = 15)	Technology	
G Rural development_Farms investments in physical assets = 7.1 (F = 22, U = 13) H Rural development_Agrifood system Investments in physical assets = 2.21 (F = 9, U = 5) I Rural development_spending efficiency = 79.54 (F = 85, U = 80) J Decrease of production cost = 40 (F = 42, U = 22) K Access to credit = 2 (F = 7, U = 2)	Economic power	Action
L Generational turnover = 13 (F = 10, U = 8) M Increase employment and local economic development = 19.6723 (F = 3, U = 7) N Internationalization --> market strategies = 0.42 (F = 10, U = 5) O Dependency ratio = 54 (F = 53, U = 59)	Flexibility	
P Education (school, University etc.) = 4.8 (F = 9.4, U = 4.8)	Knowledge	Awareness
Q Selection of products and reduction of chemical treatments = 14.8 (F = 14, U = 7) R Climate uncertainties = 90 (F = 80, U = 50) S Pollution reduction (conditionality) = 10.66 (F = 30, U = 10)	Reception/Sensitivity	
T Improving social capital (social and political participation, trust building, being part of associations etc.) = 8.38 (F = 5, U = 3) U Activism = 11.4 (F = 14, U = 9)	Social capital	





Sardinian case study : adaptive capacity

Percentage of areas irrigated with water-saving systems (e.g. drip irrigation)

Priorities		nponent
A Innovations in agricultural production systems = 43 (F = 70, U = 35) B Efficient irrigation systems = 15 (F = 25, U = 5)	Infrastructure	Ability
C Scientific knowledge development = 0.7 (F = 0.7, U = 0.4) D Public and Private investments in Research & Development (R&D) = 0.1 (F = 0.7, U = 0.4) E Innovations in systems of production_1 = 23 (F = 34, U = 24) F Innovations in systems of production_2 = 3 (F = 98, U = 15)	Technology	
G Rural development_Farms investments in physical assets = 7.1 (F = 22, U = 13) H Rural development_Agrifood system Investments in physical assets = 2.21 (F = 9, U = 5) I Rural development_spending efficiency = 79.54 (F = 85, U = 80) J Decrease of production cost = 40 (F = 42, U = 22) K Access to credit = 2 (F = 7, U = 2)	Economic power	Action
L Generational turnover = 13 (F = 10, U = 8) M Increase employment and local economic development = 19.6723 (F = 3, U = 7) N Internationalization --> market strategies = 0.42 (F = 10, U = 5) O Dependency ratio = 54 (F = 53, U = 59)	Flexibility	
P Education (school, University etc.) = 4.8 (F = 9.4, U = 4.8)	Knowledge	Awareness
Q Selection of products and reduction of chemical treatments = 14.8 (F = 14, U = 7) R Climate uncertainties = 90 (F = 80, U = 50) S Pollution reduction (conditionality) = 10.66 (F = 30, U = 10)	Reception/Sensitivity	
T Improving social capital (social and political participation, trust building, being part of associations etc.) = 8.38 (F = 5, U = 3) U Activism = 11.4 (F = 14, U = 9)	Social capital	





Sardinian case study : adaptive capacity

Percentage of farms with >10 employers having introduced technological innovations (product and process) in 3 yrs

Priorities

A Innovations in agricultural production systems = 43 (F = 70, U = 35)	Infrastructure	Ability
B Efficient irrigation systems = 15 (F = 25, U = 5)		
C Scientific knowledge development = 0.7 (F = 0.7, U = 0.4)	Technology	
D Public and Private investments in Research & Development (R&D) = 0.1 (F = 0.7, U = 0.4)		
E Innovations in systems of production_1 = 23 (F = 34, U = 24)		
F Innovations in systems of production_2 = 3 (F = 98, U = 15)		
G Rural development_Farms investments in physical assets = 7.1 (F = 22, U = 13)	Economic power	Action
H Rural development_Agrifood system Investments in physical assets = 2.21 (F = 9, U = 5)		
I Rural development_spending efficiency = 79.54 (F = 85, U = 80)		
J Decrease of production cost = 40 (F = 42, U = 22)		
K Access to credit = 2 (F = 7, U = 2)		
L Generational turnover = 13 (F = 10, U = 8)	Flexibility	
M Increase employment and local economic development = 19.67		
N Internationalization --> market strategies = 0.42 (F = 10, U = 5)		
O Dependency ratio = 54 (F = 53, U = 59)		
P Education (school, University etc.) = 4.8 (F = 9.4, U = 4.8)	Knowledge	Awareness
Q Selection of products and reduction of chemical treatments = 14.3 (F = 14, U = 7)	Reception/Sensitivity	
R Climate uncertainties = 90 (F = 80, U = 50)		
S Pollution reduction (conditionality) = 10.66 (F = 30, U = 10)		
T Improving social capital (social and political participation, trust building, being part of associations etc.) = 8.38 (F = 5, U = 3)	Social capital	
U Activism = 11.4 (F = 14, U = 9)		

Percentage of expenditure for the agro-environmental measures to the total RDP II pillar resources



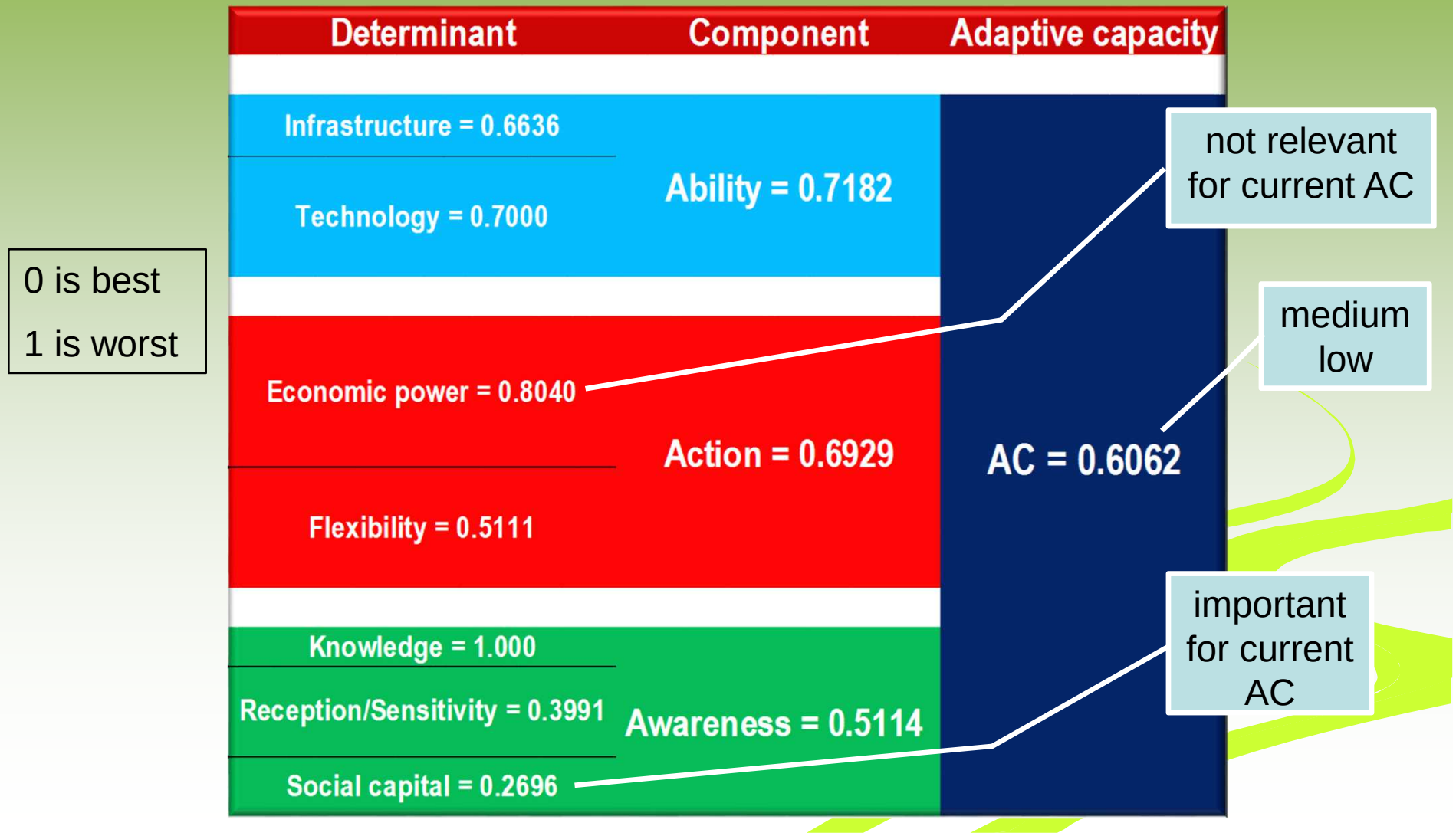


Sardinian case study : adaptive capacity

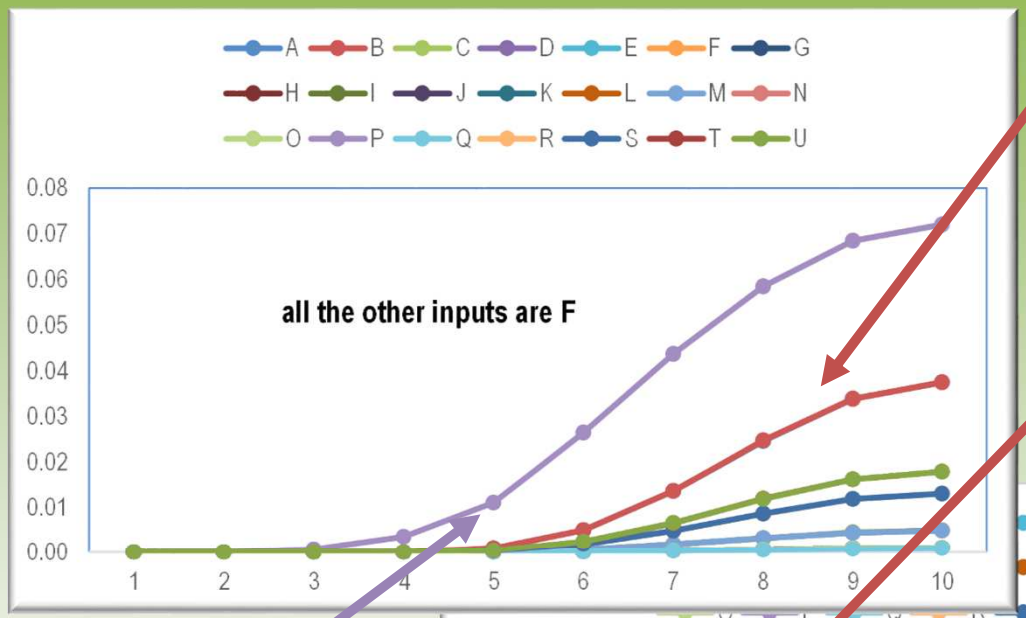
Priorities	Determinant	Component
A Innovations in agricultural production systems = 43 (F = 70, U = 35) B Efficient irrigation systems = 15 (F = 25, U = 5)	Infrastructure	Ability
C Scientific knowledge development = 0.7 (F = 0.7, U = 0.4) D Public and Private investments in Research & Development (R&D) = 0.1 (F = 0.7, U = 0.4) E Innovations in systems of production_1 = 23 (F = 34, U = 24) F Innovations in systems of production_2 = 3 (F = 98, U = 15)	Technology	
G Rural development_Farms investments in physical assets = 7.1 (F = 22, U = 13) H Rural development_Agrifood system Investments in physical assets = 2.21 (F = 9, U = 5) I Rural development_spending efficiency = 79.54 (F = 85, U = 80) J Decrease of production cost = 40 (F = 42, U = 22) K Access to credit = 2 (F = 7, U = 2)	Economic power	Action
L Generational turnover = 13 (F = 10, U = 8) M Increase employment and local economic development = 19.6723 (F = 3, U = 7) N Internationalization --> market strategies = 0.42 (F = 10, U = 5) O Dependency ratio = 54 (F = 53, U = 59)	Flexibility	
P Education (school, University etc.) = 4.8 (F = 9.4, U = 4.8)	Knowledge	Awareness
Q Selection of products and reduction of chemical treatments = 14.8 (F = 14, U = 7) R Climate uncertainties = 90 (F = 80, U = 50) S Pollution reduction (conditionality) = 10.66 (F = 30, U = 10)	Reception/Sensitivity	
T Improving social capital (social and political participation, trust building, being part of associations etc.) = 8.38 (F = 5, U = 3) U Activism = 11.4 (F = 14, U = 9)	Social capital	

Percentage of farmers with a degree

Indexing adaptive capacity

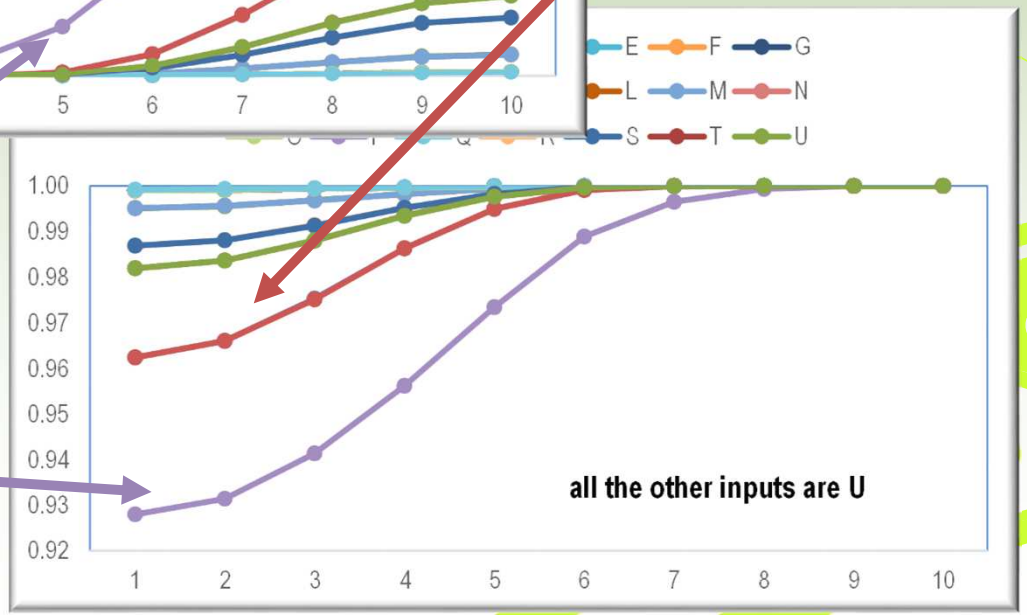


AC indicator : sensitivity analysis



Share of drip irrigation on total irrigated (data referred to the Land Reclamation Authority)

Rate of farmers' education (percentage of farmers with a degree)



Concluding remarks (1/2)

- Current adaptive capacity index of the Oristanese district is medium-low
- Social capital index is one of the strongest determinants for current AC
  - civil activism, coop and associations
- Economic power determinant is the weakest determinant
  - difficult access to credit
  - low ratio btw regional/national investments
  - low Rural Development Plan spending efficiency
  - generally low influential indicators

Concluding remarks (2/2)

- Most promising pathways for enhancing the adaptive capacity (**most influential indicators**):
  - Invest in Education
    - Education index is very weak in the region
      - high school dropout
      - low rate of graduated students
  - Invest for Efficient irrigation
    - Efficient irrigation index is very weak
      - High infrastructures costs
      - Traditional rainfed cropping systems
- The fuzzy logic-based approach proved to be a valuable tool for:
  - **Integrating quantitative data with SHs perceptions and beliefs**
  - Promoting co-**learning processes** btw researchers and SHs

Future perspectives

- To propose the implementation of this approach to policy makers in Sardinia for developing effective adaptive responses to climate change at local and regional scale

- To explore and test the application of the fuzzy logic-based approach in other agricultural districts across EU

MACSURI

a FACCE JPI Knowledge Hub

For further information

please visit: www.macsur.eu